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Development and tests of Molybdenum armed copper components for MITICA ion source

Mauro Pavei [1], Bernd Böswirth [2], Henri Greuner [2], Diego Marcuzzi [1], Andrea Rizzolo [1], Matteo Valente [1]

[1] *Consorzio RFX, Corso Stati Uniti, 4, I-35127, Padova, ITALY*
[2] *Max-Planck-Institut für Plasmaphysik, Boltzmannstrasse 2, D-85748 Garching, Germany*
Corresponding author: Mauro Pavei, e-mail: mauro.pavei@igi.cnr.it

The operation of the thermonuclear fusion experiment ITER requires additional plasma heating via injection of high energy neutral beams from accelerated negative ions; two injectors will deliver a total heating power of 33 MW.

The MITICA experiment (Megavolt ITER Injector & Concept Advancement) is the prototype and the test bed of the ITER Heating and Current Drive Neutral Beam Injectors (HNB); it is in the final design phase and will be procured and installed in PRIMA facility (Padova Research on Injector Megavolt Accelerated) in Padova, Italy.

The presence of back-streaming positive ions (BSI+), generated by secondary particle reactions in the MITICA 1 MV accelerator and scattered back at high energy towards the RF source, causes serious problems to the impinged components. In fact, the high power density deposition and the material erosion by sputtering can seriously damage the parts. Such an eroded material pollutes the plasma and it is then detrimental for the ion source operation.

A proper technical solution, based on explosion bonding technique, has been identified for the production of a 1 mm thick Mo armor layer (having molybdenum a much lower sputtering yield, compared with copper) on copper substrate, compatible with ITER requirements, but such an innovative solution needed to be validated. After having preliminarily tested the solution with thermal shock tests on small samples, larger prototypes have been recently manufactured and tested in the high heat flux test facility GLADIS to check the strength of the molybdenum-copper interface. This paper presents the experimental results as well as the results of the numerical fluid-dynamic analyses of the prototypes simulating the high heat flux test conditions in GLADIS. Moreover, the issues encountered during the production and testing of the prototypes, together with the results obtained are presented, being significant for the future manufacturing and operation of the MITICA RF source parts.

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